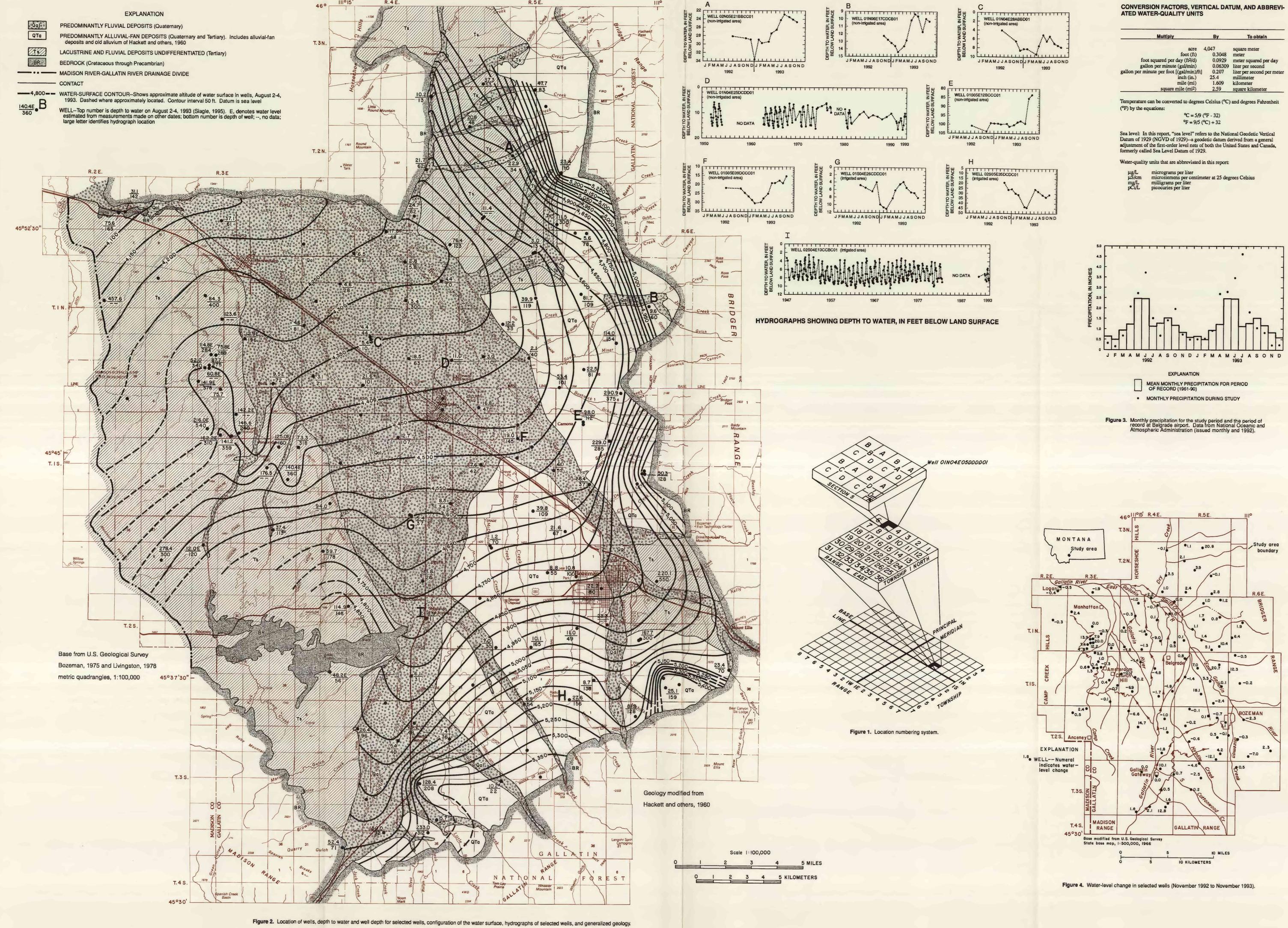
[Location number: numbering system described in text. Altitude of land surface: in feet above sea level. Primary use of water: H, domestic; I, irrigation; P, public supply; S, stock; U, unused; Z, other. Water level:

in feet below land surface. Method water level measured: R, reported; S, steel tape; T, electric tape. Discharge: in gallons per minute. Method of discharge measurement: O, orifice; R, reported; V, volumetric. Temperature: in degrees Celsius. Geologic unit: Qal, Quaternary alluvium; QTa, Quaternary and Tertiary alluvial-fan deposits; Ts, Tertiary sediments; Br, Cretaceous through Precambrian bedrock. Remarks: M, water level measured by the Montana Department of Natural Resources and Conservation; N, water level measured monthly by U.S. Geological Survey. R, well equipped with water-level recorder. Abbreviations:



The Gallatin Valley encompasses an area of about 540 mi<sup>2</sup> in the eastern half of the Three Forks structural basin, an intermontane basin in southwestern Montana. The Gallatin Valley is bounded on the north by the Horseshoe Hills, on the east by the Bridger Range, on the south by the Gallatin and Madison Ranges, and on the west by the Camp Creek Hills. The Gallatin Valley is drained by the Gallatin River and in tributaries. Principal tributaries to the Gallatin River include South Cottonwood Creek, Camp Creek, and the East Gallatin River. The largest tributary, the East Gallatin River, heads near the

southern end of the Bridger Range about 10 mi east of Bozeman

and joins the Gallatin River about 2 mi north of Manhattan. Prin-

cipal tributaries to the East Gallatin River include Bozeman Creek, Hyalite Creek, Smith Creek, and Dry Creek. The climate in the Gallatin Valley is semiarid, with cold winters and cool summers. Average annual temperatures are 41.9 <sup>o</sup>F at Belgrade and 44.2 <sup>o</sup>F at Bozeman. Average annual precipi tation in the valley ranges from about 12 in. near Logan to about 20 in. along the mountain fronts in the south and east. Annual pre cipitation in the higher elevations of the surrounding mountains is about 50 in. (U.S. Soil Conservation Service, 1977). Thirty to 35

percent of the precipitation occurs during May and June.

Population growth in the Gallatin Valley has resulted in the development of numerous rural subdivisions in an area characterized by permeable soils and shallow, unconfined aguifers that are sources of domestic water supply. Because of the consequent increased ground-water use and potential for changes in groundwater levels and chemical quality, the U.S. Geological Survey, ir cooperation with the Montana Bureau of Mines and Geology, conducted an appraisal of the current (1992-93) hydrologic conditions

#### Previous Investigations

An initial hydrologic study of the Gallatin Valley by Mur dock (1926) dealt with irrigation drainage problems. Investiga tions were later conducted by the Bureau of Reclamation (Deble and Robertson, 1937) and the history and extent of irrigation was documented by the Montana State Engineer (1953a,b). A comprehensive hydrologic study was published in 1960 as U.S. Geological Survey Water-Supply Paper 1482 (Hackett and others, 1960). The impact of land-use change on ground water was reported by Brustkern (1977). Irrigated land and rural residential subdivisions were mapped in 1985 (D.R. Johnson, U.S. Geological Survey, oral commun., 1994). Irrigation withdrawals were estimated by Parrett and Johnson (1988). The Montana Department of Natura Resources and Conservation began monitoring water levels in the Camp Creek Hills area in 1986. In 1992 the network consisted of

#### Purpose and Scope

This report describes the hydrology, including water quality of unconsolidated deposits in the Gallatin Valley and evaluates hydrologic changes resulting from changes in land use. Specific objectives are to characterize the current water levels, water-level changes, and ground-water flow system; compile information on aquifer characteristics; determine present ground-water quality; determine general land-use distribution; and evaluate any changes in geohydrologic conditions and land use.

work of the study area, 63 existing wells were inventoried to sup-

21 wells, 18 of which were irrigation wells.

# Methods of Investigation

As an initial step in establishing the geohydrologic frame-

plement data from 75 wells inventoried during previous ivestigations (table 1). Data collected included well location, altitude of land surface, use of water, depth of well, diameter of casing, water level, discharge, specific conductance, pH, water temperature, nitrate concentration, and geologic unit. A network of 30 wells was established and measured monthly for documentation of seasonal water-level changes. A network of 21 wells was measured, generally in March, May

August, and November, by the Montana Department of Natural Resources and Conservation. An additional 70 wells were measured less frequently, generally in November 1992 and May August, and November 1993. Some of the wells have been part o a statewide observation-well network. Water levels in these wells were measured as early as 1947. Records of water-level measurements are summarized in Slagle (1995). Water samples were collected from selected wells to assess sting water quality in the study area. Samples were collected

from 38 wells for laboratory analysis of major ions and trace constituents. Additionally, 16 wells were sampled for analysis of radon concentration, and 6 wells were sampled for analysis of selected pesticides and pesticide-degradation products. Generalized land use was mapped on 1:24,000-scale orthogonal

photo quadrangles from ground inventory in late summer 1993 Approved residential subdivision tracts as recorded in Gallatin County records were also mapped on 1:24,000-scale orthophoto

# **Location Numbering System**

In this report, locations are numbered according to geo graphic position within the rectangular grid system used in Montana by the Bureau of Land Management (fig. 1). The location number consists of as many as 14 characters. The first three characters specify the township and its position north (N) or south (S of the Montana Base Line. The next three characters specify the range and its position east (E) of the Montana Principal Meridian The next two characters are the section number. The next one to four characters designate the quarter section (160-acre tract), quarter-quarter section (40-acre tract), quarter-quarter-quarter section (10-acre tract), and quarter-quarter-quarter-quarter section (2.5-acre tract), respectively. The subdivisions of the section are designated A, B, C, and D in a counterclockwise direction, beginning in the northeast quadrant. The last two characters form a sequence number indicating the order of inventory. For example as shown in figure 1, well 01N04E05DDDD01 is the first well inventoried in the SE<sup>1</sup>/4SE<sup>1</sup>/4SE<sup>1</sup>/4SE<sup>1</sup>/4 sec. 5, T. 1 N., R. 4 E.

# General Geology

The Gallatin Valley is part of the Three Forks structural basin which was formed as a result of crustal movements during early Tertiary time. After formation of the basin, the valley was filled with as much as 6,000 ft of Tertiary and Quaternary sediments consisting of boulders, cobbles, sand, silt, clay, and volcanic ash (Noble and others, 1982, p. 71).

The lowermost unit of valley-fill material in the Gallatin Valley (fig. 2) is composed of Tertiary sediments ranging in age from early Oligocene to Pliocene (Hackett and others, 1960, p. I The lower Tertiary sediments primarily are of lacustrine origin and predominantly consist of sandstone, siltstone, claystone, and volcanic ash. The upper Tertiary sediments principally consist of conglomerate, sandstone, siltstone, and claystone of fluvial origin. Coalescing alluvial fans along the south and east sides of the Gallatin Valley are primarily composed of a heterogeneous mix-ture of coarse- to fine-grained sediments ranging in size from oulders to clay. Hackett and others (1960, p. 40) concluded that eposition of the alluvial fans probably was continuous from late fertiary to early Quaternary time.

The central part of the Gallatin Valley is covered by Quaternary alluvium deposited by the Gallatin and East Gallatin Rivers and their tributaries. The alluvium primarily consists of cobbles and gravel intermixed with sand, silt, and clay. Bedrock underlying the valley-fill deposits in the Gallatin Valley and exposed in the surrounding area consists of metamorphic, sedimentary, and volcanic rocks ranging in age from Precambrian through Cretaceous. Most of these rocks originated as marine sediments; notable exceptions include rocks derived from

**GEOHYDROLOGIC CONDITIONS** The valley-fill deposits of the Gallatin Valley constitute the primary aquifer utilized for irrigation and domestic supplies. The hydrologic conditions of this aquifer are described in the following sections on water levels and ground-water flow, hydraulic characteristics of the valley fill, and quality of the water.

continental deposition during Early Cretaceous time and from vol-

# Water Levels and Ground-Water Flow

canism during Late Cretaceous time.

Depth to water in the study area generally ranges from about 3 ft below land surface in much of the central part of the valley to about 460 ft in the Camp Creek Hills (fig. 2). Ground-water flow in the area generally is from the east and southeast toward the northwest where ground water exits the valley at Logan, as shown by the water-surface contours in figure 2. Locally, ground water flows toward the major drainages.

Ground-water levels fluctuate seasonally throughout the study area, generally rising from spring through mid-summer and declining during the rest of the year as shown by the hydrographs in figure 2. Because of the greater than normal precipitation throughout the summer of 1993 (fig. 3), the water levels in some wells, such as 01S05E12BCC01 and 01S05E09DCC01 (fig. 2, hydrographs E and E) reflect the effects of greater than 1990 and 1990 and 1990 are the second content of the secon hydrographs E and F), reflect the effects of greater than normal late-season recharge. The influence of irrigation on recharge to the ground-water system was well illustrated during the summer of 1993. The area received above normal precipitation and had below normal temperatures throughout the summer, which precluded the need for irrigation. Because of reduced recharge from applied irrigation water, ground-water levels declined in areas normally irrigated by diversion of surface water. In contrast, water levels rose more than normal in non-irrigated areas and in areas irrigated by wells, primarily the Amsterdam-Manhattan area. Between November 1992 and November 1993 declines of as much as 12.1 ft at well 02S05E35DCDC01 occurred in the irrigated areas and rises of as much as 20.8 ft at well 02N05E04DADD01 were recorded in the non-irrigated areas (fig.

Although seasonal water-level fluctuations are large in some areas, the long-term water-level change generally is minimal. The hydrograph for well 02S04E13CCBC01 (fig. 2, hydrograph I) shows annual fluctuations in an irrigated area between about 1.5 and 6.5 ft and year-to-year fluctuations of about 1 ft for the period 1947 through 1993. The mean annual (year-toyear) water level for 1993 is essentially the same as that for 1948. Comparison of water levels in wells measured during this study Slagle, 1995) and by Hackett and others (1960) indicates a small decline in water levels between November 1952-53 and November 1992 (table 2). However, the hydrograph for well 02S04E13CCBC01 indicates that 1952-53 mean annual water levels were some of the highest for the period of record and also somewhat higher than the 1993 water levels. Comparison of the configuration of the water surface shown on figure 2 and the water surface for August 1, 1953 (Hackett and others, 1960, pl. 5) indi-

# Hydraulic Characteristics

cates little change throughout the study area.

Specific-capacity tests (table 3) indicate that the Quaternary

alluvium generally is the most permeable material in the study area. Specific-capacity values from tests of 26 wells completed Quaternary alluvium ranged from 0.46 to 63.2 (gal/min)/ft, with a median value of 4.6 (gal/min)/ft. Transmissivity values determined by Hackett and others (1960, table 12) for Quaternary alluvium, ranged from 5,100 to 90,000 ft<sup>2</sup>/d. Specific-capacity values from tests of 21 wells completed in alluvial fan deposits in the southern and eastern parts of the study area generally ranged from 0.19 to 23.8 (gal/min)/ft, with a median value of 1.6 (gal/min)/ft. An anomalously large value of 300 (gal/min)/ft was determined for one well completed in alluvial fan deposits. Transmissivity values for the alluvial-fan deposits determined by Hackett and others (1960) ranged from 600 to 8,700 ft<sup>2</sup>/d. Specificcapacity tests were conducted on 16 wells completed in Tertiary sediments; the values ranged from 0.20 to 47.6 (gal/min)/ft, with a median value of 0.78 (gal/min)/ft. Transmissivity values determined by Hackett and others (1960) for Tertiary sediments ranged

# Water Quality

from 40 to  $3,500 \text{ ft}^2/\text{d}$ .

Water from 38 wells in the Gallatin Valley was sampled and analyzed by the laboratory of the Montana Bureau of Mines and Geology for primary constituents and trace elements. The water generally was a calcium bicarbonate type having dissolved-solids concentrations ranging from 113 to 551 mg/L, with a median value of 252 mg/L (table 4). Water from four wells (01S04E17-DCDD01, 01S06E06ABCB01, 01S06E20BDAA02, and 02S05E17BBAA01) was a calcium magnesium bicarbonate type and water from two wells (02S05E31ADAA01 and 03S06E05CBAA01) was a magnesium calcium bicarbonate type. Water from only one well (02S04E05BCBB01) had a dissolved-solids concentration (551 mg/L) in excess of the drinking-water regulation for public water supplies of 500 mg/L (table 5) established by the U.S. Environmental Protection Agency (1991a). Water from all other wells sampled, except well 02S05E31ADDA01 with a concentration of 437 mg/L, had dissolved-solids concentrations less than 400 mg/L. Maximum concentrations for all other constituents analyzed (table 4) were considerably less than the maximums for drinking-water regula-

Sixteen wells were sampled to assess the concentration of radon-222 in ground water in the Gallatin Valley. Radon concentrations in water from the sampled wells ranged from 170 to 1,565 pCi/L with a median concentration of 523 pCi/L (table 4). Montana Water Quality Standard for Human Health is 300 pCi/L for public water supplies. Although 94 percent of ground-water samples from the Gallatin Valley exceeded this concentration, ingestion of water containing radon is considered to be a minor health risk compared to the risk from breathing air containing radon (U.S. Environmental Protection Agency, and others, 1992). The standard of 300 pCi/L is recommended in public water supplies to minimize the amount of radon released to household air Radon concentrations as large as 9,900 pCi/L have been detected from wells sampled in other parts of southwestern Montana and concentrations exceeding 1,000,000 pCi/L have been detected in water from wells in some parts of the United States (Clark and

To assure the reproducibility of analyses of water samples collected during this study, duplicate samples were collected for each 10 samples or at least once for each sampling trip and submitted to the Montana Bureau of Mines and Geology laboratory for analysis. Additionally, for each 20 samples collected, a triplicate sample was collected and submitted for interlaboratory comparison to the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colo. Results of constituent analyses by the laboratories were consistent. Results of the quality-control analyses are given in table 6.

Water samples were collected from six wells to determine

possible presence of selected pesticides or pesticide-degradation products in ground water. Two wells (01S04E26CDDD01 and

#### 01S04E26CDDD02) are located in an area downgradient from a former aerial spraying operation, one well (01S05E15BCBA01) is located in a developed subdivision, one well (02S05E11ADAB01) is located in a city park, and two wells (02S05E17BBAA01 and 03S04E03ABAA01) are located in agricultural areas. Analyses for the 54 pesticides and pesticide degradation products listed in table 7 were conducted by the Monana Department of Agriculture laboratory in Bozeman. Labora-

Water from 43 wells was analyzed semi-quantitatively for nitrate concentration (table 1). Analysis was conducted onsite using a spectrophotometer. The meter was calibrated using a 10 mg/L nitrate standard solution. Nitrate concentrations (as nitrogen) ranged from 0.1 to 4.5 mg/L, with a median concentration of 1.4 mg/L. Water from 30 of the 43 wells contained concentrations

tory quality assurance consisted of a duplicate analysis of one

sample from each sample set. No pesticides or related analytes

# LAND USE

were detected in any of the samples.

Agriculture is the predominant land use in the study area g. 5). Small grains, particularly wheat, are the principal crop in e non-irrigated parts of the valley. The principal irrigated cre is hay, although potatoes are irrigated, mostly by ground water, in the Camp Creek Hills area. About 96,200 acres were under irrigation facilities in Gallatin County in 1985 (Parrett and Johnson, 1988; D.R. Johnson, U.S. Geological Survey, oral commun., 1994); most of those acres are in the Gallatin Valley. About 2,750 of the 96,200 acres commonly are irrigated with ground water. Hackett and others (1960) reported that 107,261 acres were irrigated in 1952 in the Gallatin Valley. Because most of the acreage irrigated in 1985 is in the Gallatin Valley, it is assumed that most of the reduction in irrigated acreage from 1952 to 1985 occurred in the Gallatin Valley.

The population of the area has grown significantly in 40 years. The population of Gallatin County increased from 21 in 1950 (Hackett and others, 1960) to 50,463 in 1990 (I Department of Commerce, 1992). The City of Bozeman increased from 11,325 to 22,660 residents during the same period. The population growth has resulted in many new areas of urban use including the establishment of numerous rural residential subdivisions in the valley (fig. 5). Most homes in these subdivisions have individual wells and septic systems. The density of development results in increased use of ground water, which is the source of domestic water supply for most of the residents in the valley. Septic systems and excess application of pesticides and fertilizers to lawns and gardens could increase the potential for ground-water contamination, particularly in areas where soils are permeable and the aquifer is shallow and unconfined.

#### RELATION OF LAND USE AND GROUND-WATER CONDITIONS

Water-level measurements made during this study, coupled with long-term water-level trends (fig. 2), do not indicate any significant water-level changes resulting from increased ground-water withdrawals. Water-level altitudes and annual fluctuations are similar to those measured in 1952-53. Perhaps the greatest influence of land use on ground-water levels is the dependence on irrigation to provide recharge to sustain artificially high water levels in areas irrigated with surface water.

Distribution of nitrate concentrations in ground water indi-

cates the possibility of an influence of rural residential development on ground-water quality. Most of the samples containing larger concentrations of nitrate ranging from 2 to 4.5 mg/L were from wells north-northwest of Bozeman in the general vicinity of the eastern part of T.1 S., R.5 E. (fig. 5), one of the more densely developed areas in the valley. These larger nitrate concentrations, while considerably less than the 10 mg/L maximum established by the U.S. Environmental Protection Agency (1991a) for public water supplies, may reflect the greater density of septic systems or

The Gallatin Valley is part of an intermontane basin in southwestern Montana, encompassing an area of about 540 mi<sup>2</sup>. The valley is drained by the Gallatin River and its tributaries. The climate is semiarid with average annual precipitation ranging from about 12 in. at the western edge of the valley near Logan, to about 20 in. along the mountain fronts in the south and east. The Gallatin Valley is part of the Three Forks structural basin, which was formed during early Tertiary time. After formation of the structural basin, the Gallatin Valley was filled with as

iments consist of various heterogeneous mixtures of boulders. cobbles, sand, silt, clay, and volcanic ash. Depth to water in the study area generally ranges from about 3 ft to about 460 ft below land surface. Ground-water flow generally is from the east and southeast toward the northwest where the water exits the valley at Logan. Ground-water levels fluctuate seasonally, generally rising from spring through mid-summer and declining during the rest of the year. Although seasonal waterlevel fluctuations are large in some areas, long-term water-level change generally is minimal.

Specific-capacity tests indicate that the Quaternary allu-

vium generally is the most permeable material in the area. The

median specific capacity of 26 wells completed in the alluvium was 4.6 (gal/min)/ft. The median specific capacity of 21 wells

much as 6,000 ft of Tertiary and Quaternary sediments; these sed-

completed in Tertiary and Quaternary alluvial-fan deposits in the southern and eastern part of the area was 1.6 (gal/min)/ft whereas the median value of 16 wells completed in the Tertiary sediments Water from 38 wells sampled for water-quality analyses generally was a calcium bicarbonate type, having dissolved-solids concentrations ranging from 113 to 551 mg/L. Water from only two wells had dissolved-solids concentrations greater than 400 mg/L. Radon-222 concentrations in water from 16 wells ranged from 170 to 1,565 pCi/L. Water samples collected from 6 wells were analyzed for 54 pesticides and pesticide-degradation products. No pesticides or related analytes were detected in any of

those samples. Nitrate concentrations measured onsite using a

spectrophotometer ranged from 0.1 to 4.5 mg/L in water from 43

Agriculture is the predominant land use in the Gallatin Valley. However, population growth has resulted in the establishment of numerous rural subdivisions. Water-level measurements made during this study, coupled with long-term water-level trends, do not indicate any significant water-level changes resulting from increased ground-water withdrawals. The occurrence of larger nitrate concentrations in ground water in more densely developed areas indicates a possible influence of subdivision development on ground-water quality. However, the maximum concentration detected (4.5 mg/L) is considerably less than the 10 mg/L maximum established by the U.S. Environmental Protection Agency for public water supplies.

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Table 1. Records of selected wells in the Gallatin Valley

Location number	Altitude of land surface (feet)	Primary use of water	Depth of well (feet)	Diameter of casing (in.)	level (feet)	Method water level meas- ured	Date water level meas ured		of dis- charge meaa- ure- ment	Specific conduc- tance, onsite (µS/cm)	pH, onsite (atandard unita)	Temper- ature (°C)	Nitrate, onsite (mg/L as N)	Date water- quality parameter measured	Geologic unit	Rem
1N02E14CADC01 1N03E07CDDA01 1N03E16CABB01 1N03E21ADDD01 1N03E27AACC01	4,620 4,422 4,375 4,433 4,329	U S U I I	400	6.0 6.0 16  16	458.6 227.89 84.56 121.20 14.36	S S S S	06-24-91 11-04-92 05-14-91 05-02-91 05-15-91	2,000	- - - R		=		-		Ts Ts Ts Ts Ts	N N
1N03E28DCAA01 1N03E28DCBB01 1N03E33BADD01	4,420 4,460  4,420	I I	289 284  275	16 16  16	77.30 115.39  78.92	S S  S	05-14-91 05-14-91  05-14-91	2,000 1,400 1,500 1,680	R R R	-	 	  	=	<u></u>	Ts Ts Ts Ts	N
1N03E33BD 01 1N03E33BDBB01 1N03E33CCBC01 1N03E35DDBB01	4,440 4,435 4,520 4,351	U I I	340 378 72	6.0 12 16 16	73.50 17.42 145.08 11.45	T S S	10-24-89 05-14-91 05-14-91 05-15-91	1,000 900	- R R		- - -	=	=		Ts Ts Ts Qal	N N N
N04E01DBAB01 N04E03BBAA01 N04E05DDDD01	4,385  4,270 4,257	H  U H	123  48 65	6.0  4.0 6.0	75.73  19.00 8.21	S  S S	06-20-91  04-24-51 06-24-91	7 15 30	V R	309 462	7.5  7.5	12.0	-	06-19-91  06-24-91	Ts Ts Qal Ts	N
N04E06CBBB01 N04E10AADD01 N04E12CDCC01	4,228 4,277 4,309	u u	8.2 5.8 7.0	1.0 1.2	4.99 2.66 5.43	S S	06-18-92 06-18-92 08-14-92	10	V - -			=		=======================================	Ts Qal Qal Qal	N N
N04E15DADD01 N04E17BAAA01 N04E18DBCC01 N04E19CBCC01	4,318 4,278 4,288 4,304	U H H U	300 28 33 81	6.0 6.8 6.0 6.0	5.00 3.75 5.63 4.00	S S S	05-20-53 06-11-92 07-15-92 09-01-53	12 5.4	v v	411 364	7.2 7.6	8.5 9.0	0.6 .9	06-11-92 07-15-92	Qal Qal Qal Qal Qal	N N
N04E25DCDD01 N04E26CCCC01 N04E28ABBB01 N04E28ABBD01 N04E31CAAA01	4,385 4,384 4,349 4,352 4,361	U U H Z	101 63 44 10	6.0 6.0 6.0 18 3.5	10.57 17.94 3.54 4.00 2.96	S S S S S S	12-07-51 07-14-92 07-14-92 07-14-92 06-18-92	140 20 5.2	V V V	426 608 298	7.6 7.4 7.3	11.0 10.0 14.0	 1.5 .9	12-07-51  07-14-92 07-14-92	Qal Qal Qal Qal	R
N04E33CDCC01 N05E02AAAC01 N05E02BAAD01 N05E04DDAD01	4,407 4,740 4,675 4,500	I H H U	101 78 40 13	16 5.0 6.0 10	21.85 6.12 5.97 11.37	S S S	06-19-91 07-22-92 06-20-91 07-17-92	1,500 13 25	R V R	185 240	7.0 7.0	10.0 10.0	.5 .9 	06-18-92  07-22-92 06-20-91	Qal Qal QTa QTa	
N05E04DDAD02 N05E14ACDD01 N05E16DAAA01	4,670 4,490	Н Н Н	68 109 119	6.0 6.0 6.0	7.46 86.32 43.33	SSS	07-17-92 07-31-92 06-21-91	8.0 13 7	V V V R	650 429 461	7.6 7.6 7.1	10.5 10.0 8.0	1.3	07-17-92 07-31-92 06-21-91	Qal Qal QTa Ts	N
N05E20DBAA01 N05E28DCAD01 N05E30DDAA01 N05E34DDDC01	4,377 4,423 4,380 4,519	H H U H	33 40 10 101	6.0 6.0 1.0 6.0	12.86 4.45 3.00 64.35	S S	07-15-92 07-08-92 07-07-51 06-20-91	8.6 14	V V	348 435	7.8 7.7	8.5 8.5	1.6 2.7	07-15-92 07-08-92	Ts QTa Qal Qal	N
N05E35ADBB01 N06E17CDCB01	4,565 5,040 4,695	H H	81 60	6.0 6.0	25.59 10.77	s s	07-22-92 06-20-91	6.6 14 30	V V R	315 427 328	7.7  7.9 7.4	9.0 10.5 7.5	3.1	06-20-91 07-22-92 06-20-91	QTa QTa QTa QTa	N
02E01BDDD01 03E03BBB 01 03E09DBC 01 03E10AB 01	4,695 4,440 4,560 4,450	Î - - -	710 540	26 6.0 16 6.0	303 81.00 233.70 105.88	R T S T	07-16-92 11-15-76 01-16-90 07-27-90 03-19-90	6.7 1,850  	V R - -	570 388  	7.6 7.8  	9.5   	3.5	07-16-92 08-14-91  	QTa Ts Ts Ts Ts	M
03E10CCC 01 03E10DCCB01 03E10DDBB01 03E13BDBD01 03E23ADBC01	4,580 4,550 4,535 4,552 4,670	I U I	310 359 240 160 392	6.0 16 16 8.0 16	159.75 140.47 148.25 108 177.64	S S R S	10-28-89 05-14-91 05-02-91 02-01-74 05-14-91	900 630  600	R R R		-		=		Ts Ts Ts Ts	M M M
03E24DBAB01 03E36BCCD01 04E01DCBD01	4,633  4,658 4,459	U  U P	360  113 185	16  8.0 12	142.79  14.00 54.73	S  S S		1,150 750	R R						Ts Ts Ts Ts	M M
04E09BAAA01 04E10DDDD01 04E12CAAB01 04E17DCDD01	4,428 4,488 4,480 4,497	U H P S	97 107 260 50	6.0 5.5 12 6.5	23.00 12.15 53.40 6.52	S S R	04-08-53 07-30-92 02-04-88	15 725	R V	379 432	7.5	9.5 10.5	.8	07-30-92 06-19-91	Qal Qal Qal Qal	N
04E18BCB 01 04E25ADDD01	4,520 4,581 4,605	й н	318 34 37	16 6.0 5.5	70.64 7.76	S T S	06-18-92 11-21-89 07-29-92	7.5	v - - v	553  374 457	7.6 7.3 7.5	9.0 10.0 10.0	1.5	06-18-92 07-29-92 07-30-92	Qal Ts Qal	M
ME26CDDD02 ME29BDCD01 ME05CCBB01 ME09ACCC01	4,605 4,670 4,451 4,475	I U H H	27  47 28	4.0  5.5 4.0	6.62 69.48 17.86 19.93	S S S	07-13-93 05-14-91 07-23-92 07-09-92	12	v	431  403 465	7.7  7.6 7.5	9.5  10.0 6.5	2.4  1.4 1.8	07-13-93  07-23-92 07-09-92	Qal Ts Qal Qal	M
5E09DCCC01 5E12BCCC01 5E12BCCC02 5E15BCBA01 5E16DBCC01	4,490 4,668 4,669 4,518 4,525	U S H H	145 112 120 60 58	6.0 6.0 6.0 6.0	16.00 100.73  28.87 37.24	S S S	10-26-53 07-09-92  07-13-93 06-18-91	9.2 45	v R	375 532 575	7.6 7.3 7.3	10.0 9.0 9.5	3.9 2.9	 07-09-92 07-13-93 06-18-91	Qal QTa QTa Qal Qal	N N -
05E17CCDC01 05E22AADD01 05E24CACD01	4,519 4,567 4,628	H H H	42 52 37	5.5 6.0 5.0	9.05 3.86 27.73	SSS	07-31-92 07-23-92 07-29-92	19 12 12 5.4	V V V	347 623 553	7.2 7.6 7.5	8.5 8.5 10.5	1.0 2.8 4.5	07-31-92 07-23-92 07-28-92	Qal Qal Qal Qal	-
5E27CBDC01 5E35CAAB01 6E06ABCB01 6E18BBBB01	4,665 4,695 4,878 4,850	H H H	67 375 285	6.0 6.6 6.0	46.31 19.08 281.45 213.91	S S T S	08-06-92 08-18-92 07-16-92 06-20-91	12 15 12 60	V V V R	598 505 290 405	7.6 7.5 7.8 7.4	8.5 8.0 10.0	1.6 3.3 .3	08-06-92 08-18-92 07-16-92 06-20-91	QTa QTa QTa QTa	
6E20BDAA01 6E20BDAA02 6E20BDAB01	5,150 5,150 5,135	H H H	110 128 166	6.0 6.0 6.6	39.39 45.62 38.38	S S S	06-20-91 11-04-92 06-20-91	9.1 3 11 20	V R V R	285 276	8.1 7.8	9.0 10.0		07-21-93 06-20-91	QTa QTa QTa QTa	N N
E20CBDD01 2E35ADDA01	5,090	н 	230	6.0	88.42  72.43	S S	06-20-91	9.1 8 1.7	V R V	502	7.4  7.5	11.0 - 9.5		06-24-91	QTa QTa QTa	:
E36BCAA01 BE33DADD01	4,102 4,203	H Ū	142  61	6.0	22.27 34.00	s  s	06-25-91	6.0 15 2.4	V R V	616	7.4	12.0		06-25-91	Br Ts Ts Qal	N
4E02DDDB01 4E23DBDD01 4E35BDCC01 5E04DADD01	4,599 4,442 - 4,338 5,310	U H  I H	13 62 62 83	6.0 6.0 6.0	11.00 18.57  22.58 59.15	S - S S	05-28-51 06-24-91  08-14-92 06-21-91	6.7 12 12 30	V R V R	601  529 329	7.3  7.5 7.5	10.0  10.0 8.5	  .8	06-21-91  08-14-92 06-21-91	Qal Ts Ts Qal Ts	N - - N
05E06ADDA01 05E10BDBD01	4,892 5,530	H H	53 294	6.0	37.85 253.95	S S	06-21-91 06-21-91	10 30 25 6.7	V R R V	412 305	7.3 7.6	11.5 8.0		06-21-91 06-21-91	Ts Ts Ts Ts	:
05E18ABBB01 05E21BBCC 01 05E22DDAD01 05E31DAAA01	4,782 4,972 5,285 4,508	H U H U	48 34 110 20	5.0 6.0 6.0 18	22.37 28.00 23.32 15.82	S S S	08-05-92 05-28-51 07-31-92 08-04-92	6.0	v	430  243 790	7.7  7.5 7.5	9.0  10.5 10.5	2.1  .1 .5	08-05-92  07-31-92 08-04-92	Ts Qal QTa	N -
3E04BAAD01	4,508 4,740  4,605	H I  I	110 300	6.0	13.01	S	06-20-91  05-15-91	25	R V	454 283	7.9 7.6	11.0 11.0	.8	08-04-92 06-20-91	Qal Ts Ts	:
3E06DACD01 4E05BCBB01 4E11ADDD01	4,810 4,780 4,693	S H 	300 178 		259.47 58.00 	S S	10-28-92 06-23-91	30 8.9	R	711	7.5 	10.0		06-23-91	Ts Ts Ts Ts	M - -
ME13CCBC01 ME16BCCA01 ME29CDDC01 ME35ABBB01	4,738 4,983 5,221 4,825	U S H	11 148 56 31	12  6.0 6.0	3.30 108.25 39.35 4.78	S S S S	08-11-92 06-21-47 08-11-92 06-23-91 08-17-92	6.9 5.7 6.3	V V V	440 199 419	7.8 6.7 7.6	12.5 10.0 9.5	   1.0	08-11-92 06-23-91 08-17-92	Qal Qal Ts Ts Qal	N -
05E05ABBB01 05E05ABBD01 05E10AABB01	4,688 4,686 4,785	H  H  P	40 70  55	6.0 6.0 - 5.5	6.25  2.79  10.41	S S S	06-23-91 06-23-91  08-18-92	25 7.1 45 11	R V R V	420  268  480	7.2 7.7 7.7	9.5 10.5  10.0		06-23-91 06-23-91  09-03-92	Qal Qal Ts Ts	:
05E11ADAB01 05E12DACC01 05E17BBAA01	4,810 4,835 4,810	I I H	100  80 39	6.0 6.0 6.0	12.80 25.55 18.65	S S S	10-24-88 	40 114 50 3.7	O R V	520  472	7.2	9.5  10.5	- - - .3	07-14-93  08-18-92	QTa QTa QTa QTa	N :
05E20DDCC01 05E22CCDC01 05E23AADD01	4,945 4,995 4,962	H  H S	30 165 49	6.0 6.0 5.5	5.22 10.78 5.89	S	06-23-91 03-09-53 08-19-92	7.4 12	R V V	433  455	7.6	8.5 7.5	 1.0	06-18-92 06-23-91	QTa QTa QTa QTa	N
05E31ADDA01 05E35DCDC01 05E36BACD01 06E08ADDA01	4,078 5,203 5,111 5,090	H I I H	125 156 138 550	4.0 12 12 6.0	30.58 35.68 11.31 223.05	SSS	08-17-92 05-14-51 10-26-88 06-24-91	7.1	V - R	596  372	8.0  7.6	9.0  11.0	1.5	08-17-92  06-24-91	QTa QTa QTa QTa Ts	N N
06E19BBBB01 06E20CABD01 06E20CACA01	4,919 5,100 5,132 5,150	U H H	300 238 70	6.0	23.59 140.90 167.03	SSSS	10-27-92 06-22-91 06-22-91 06-23-91	6.7 15	V R	345 472	7.8 7.5 7.0	9.5 9.5		06-22-91 06-22-91	QTa Ts Ts	N
06E33ADAC01 06E33BABD01 06E33BDDC01	5,420 5,440 5,435	U H U	176 305 159	6.0 6.0 6.0	88.37 126.44 31.71	SSS	06-22-91 06-22-91 06-22-91	20 23 15	R R R R	364	7.0  7.5	7.0  8.5 		06-23-91  06-22-91 	QTa QTa QTa QTa QTa	N
04E02DCAD01 04E03ABAA01 04E09ABBC01 04E11CBBA01	4,940 4,390 4,955 4,910	H H H	48 23 96 40	6.0 6.7 6.0 6.0	26.95 8.19 23.99 5.48	S S S	08-04-92 07-13-93 07-29-92 06-18-91	10 12 6.7 80 12	V V V R	360 371 387 541	7.7 7.7 7.5 7.2	8.0 7.5 8.5 7.0	1.7 1.5 1.1	08-04-92 07-13-93 07-29-92 06-18-91	Qal Qal Ts Qal	- N -
04E21DDBD01 04E23AADC01 04E25DBBD01	5,031 5,460 5,285	I H H	105 208 50	16 6.0 6.0	26 130.02 15.81	R S S	03-31-71 07-29-92 06-18-91		R V R V	310 374 299	7.5 7.8 7.2	7.0 8.5 .5.5	2.1	06-18-91 07-29-92 06-18-91	Qal QTa QTa Qal	·
04E34ABBB01 04E36BABB01	5,150 5,122 5,487	H  H H	71 92 312	6.0	53.28  46.11 233.40	S S S	06-18-91  07-28-92 06-18-91	8.6 6.7 10 6.0 17	V R V	576 354 340	7.1  7.4 7.2	9.0  9.5 9.5	  2.4	06-18-91 07-28-92	Qal Ts Ts Qal QTa	:
605E04AAAD01 605E07BCCC01 605E10CCCB01	5,170 5,100  5,312	H H  H	54 36 - 70	5.5 6.0	4.79 3.87 41.66	S	06-18-91 08-19-92 06-18-91	20 12 30 5.0	R V V	300 235	7.1 7.5	9.5 7.5 7.5	3.0	06-18-91 08-19-92 06-18-91	QTa QTa Qal Qal QTa	:
S05E10CCCB01 S05E21BBBA01 S06E05CBAA01	5,312 5,375 5,230	H H	70 22 128	6.0 5.5	41.66 8.27 82.14	S S	06-22-91 08-04-92 08-19-92	5.0 8.0	v v	464 315 262	7.5 7.7 7.4	8.5 9.0 8.0	.6 	06-22-91 08-04-92 07-20-93	QTa Qal QTa	:

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